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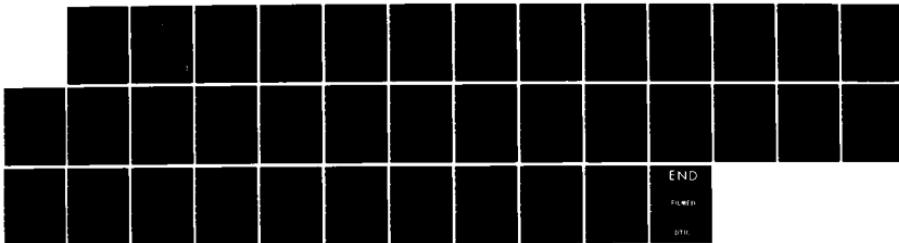
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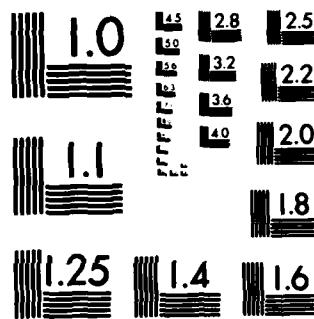
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THE POTENTIAL FOR ADVANCED COMPUTERIZED AIDS FOR  
COMPREHENSIBLE WRITING OF TECHNICAL DOCUMENTS

AD-A150 501

David E. Kieras

University of Michigan

Technical Report No. 17 (TR-85/ONR-17)

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## ABSTRACT

It is widely agreed that technical documents for equipment are poorly written and hard to comprehend. This has been a long-standing problem because the information-processing demands of editing and revision are so high that many comprehensibility problems go undetected. However, many of these problems can be detected by computerized systems that scan a document and point out where the writing can be improved. Existing systems of this type are based on conventional writing customs, rather than on the research literature on comprehension, and so either give poor advice or miss important problems. They also do not process the input document to any depth. An approach to advanced writing aids is described; such a system would base its criticisms on what is known about the cognitive psychology of comprehension, and would make use of techniques from Artificial Intelligence for processing the language. Some examples of the relevant research results are presented, and a demonstration system of this type is briefly described.

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## THE POTENTIAL FOR ADVANCED COMPUTERIZED AIDS FOR COMPREHENSIBLE WRITING OF TECHNICAL DOCUMENTS

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It is generally agreed that most technical manuals for military equipment are not very comprehensible and thus tend to be unused (Bond and Towne, 1979). Figure 1 is an excerpt from a typical military equipment manual. One can see that the sentence structure is often convoluted, even though this manual is an important and mature document. Since many users of technical documents are relatively poor readers, especially in the military, this lack of clarity is a serious impediment to using the manuals, even if the reader has adequate background knowledge. Thus improving the comprehensibility of such documents is largely a matter of improving the clarity of the writing, rather than changing the content. This paper describes an approach to developing advanced computer-based systems that will assist writers in preparing more comprehensible technical documents.

### THE NEED FOR COMPUTERIZED WRITING AIDS

For many years there have been guidelines available that are intended to help technical writers write in a more comprehensible fashion. Despite the long availability of guidelines, the quality of technical documentation is still in need of substantial improvement; why don't guidelines help? Of course there are many problems, some essentially political, which make it difficult to bring about a fundamental change in how documentation for equipment is prepared. However, one possibility for why guidelines have been ineffective could be due to the psychological properties of the writing and editing tasks.

Some studies conducted by Wright (in press) suggest that correcting text according to a set of guidelines is in fact a very difficult and complex skill. She found that there was little consistency between professional editors in their evaluations and revisions of a manuscript. But since technical documents are often written by individuals with no formal training in writing, Wright's studies involving ordinary people as subjects are especially important. One group was given a set of six guidelines, with examples, and asked to revise a short passage with the guidelines in hand. The writing guidelines covered several important and commonly accepted features of clear writing, such as avoiding long modifying strings, passive verbs, and unnecessarily long words. Another group performed the same task but without the guidelines.

**2-4-3. PRIMARY POWER MODE.** The primary power mode is a cage mode wherein initial application of power to SINS is accomplished. The primary power mode is entered when the PRIMARY POWER (MODE SELECTOR) pushbutton of the NCCP is pressed. During the primary power mode, the platform is coarse leveled by the pendulous leveling resolvers and coarse aligned in azimuth by the DEPTH and HEADING data converter monitor drawer. The platform will drive to the indicated heading when a cage mode is selected. The platform temperature alarm circuits are activated, causing the platform temperature alarm lamp to flash until the binnacle temperature is within its operating range. The gyro bottoming circuits and alarms are deactivated. The velocity meter and gyro pump power supply is turned on. The power relays in the navigation console connect 115v 400-Hz 3-phase power to the SINS power supplies and 115v 60-Hz 3-phase power to the SINS blowers. MARDAN memory precision power is also applied in the primary power mode.

Figure 1. An excerpt from a military equipment manual.

The guidelines did have an effect, in that roughly twice as many modifications to the text were made by the subjects with the guidelines. However, even the subjects with the guidelines made only 39% of the changes to the text that the guidelines addressed. Thus, the majority of the writing problems in the text were left unchanged even by those subjects who had the guidelines before them at all times.

This is a startling result; it suggests that guidelines do not help because it is very difficult to detect problems in writing. But this follows from the currently accepted idea that much of the reading process is very highly automated. In order to spot a comprehensibility problem, an ordinary reader would have to notice that the normally subconscious automatic reading mechanisms were having difficulty. Since the person responsible for writing a technical document is likely to be a very skilled reader, and be familiar with the subject matter, he or she will have no problems comprehending the material, even if it presents serious problems for the naive or poor reader. The result is that writers will fail to detect most of the comprehensibility problems in their work. People who are good copy editors have probably developed very specialized skills, such as being able to monitor their comprehension processes, or read in some sort of non-automatic mode.

Thus efforts to improve the comprehensibility of technical documents by providing guidelines will probably continue to be unsuccessful, although systematic training in writing may gradually increase the pool of good technical writers.

A computerized writing aid that detects comprehensibility problems would clearly be an advantage simply because it would perform the detection problem much more rapidly and reliably than most human writers could do. This is a difficult task for a writer, because it involves undoing or modifying a very highly developed and automated skill of reading. However, if a computer can perform at least most of this process, it would free the writer to exercise his or her writing skill in correcting the problems once they were detected. The correction process is still in the domain of skills which are only humanly possible. However, the detection process is within reach of current computer technology.

#### CURRENT WRITING AIDS

Two major computerized writing aids already exist. One is the Computerized Readability Editing System (CRES) developed by Kincaid and his co-workers (Kincaid, Aagard, & O'Hara, 1980; Kincaid, Aagard, O'Hara, & Cottrell, 1980; Kincaid, Cottrell, Aagard, & Risley, 1981; ). The other is the Writers Work Bench (WWB) developed by Bell Laboratories (Cherry, 1982; Macdonald, Frase, Gingrich, & Keenan, 1982).

Both CRES and WWB are intended to be used on a computer as part of a general word processing and document preparation package. After preparing a draft of a document, the writer feeds it into the system, and obtains output about the quality of the writing. The CRES system provides an annotated copy of the original document, with specific problems pointed out, and some global information, consisting of the Kincaid-Flesch readability score, and a list of the words appearing in the text that are not on the standard military vocabulary list. The specific feedback consists of several useful items. Sentences of excessive length are flagged, along with the number of words in the sentence. The use of the passive voice is pointed out, along with strings of words that involve too many prepositions, which are often associated with awkward phrases. Simpler wording is pointed out. For example, use is suggested as a replacement for utilize.

The WWB system is actually a family of programs that are based on an ingenious algorithm that can classify words in a text according to their parts of speech using very little lexical information. However, the feedback provided to the writer by WWB, at least as described by Cherry and Macdonald, et. al., seems to be no better than the CRES system, and in some ways worse. The basic theme of WWB seems to be providing global statistical information about a document, rather than exact criticism. For example, one program provides the scores for several readability formulas, along with such statistics as the proportion of words appearing as various parts of speech, such as what percentage of the text are adjectives. The guidance for how such information should be used is of dubious value; for example, Cherry (1982) suggests that if the ratio of adjectives to nouns is excessive, it is a sign of poor writing. Another program compares the statistics for a document with those for one that has been chosen to represent good documents of that type. For example, the program will inform the writer of an interoffice memo that his or her memo has more uses of the passive voice than a good interoffice memo. Another program flags problems in a manner similar to the CRES system, but does not appear to be as comprehensive.

#### PROBLEMS WITH CURRENT SYSTEMS

The fundamental problem with both CRES and WWB is that they are not based on the actual psychology of comprehension, but rather on ordinary writer's intuitions, many of which are incorrect or inapplicable in terms of what is known about comprehension. These intuitions, which inspire the guidelines, seem to be based both on ideas about what is clear writing, and also artistic customs about what constitutes good literary style. For example, many textbooks on writing will recommend that one use variety in sentence length, and variety in forms of reference as well. Thus, in the paper on WWB by Cherry (1982), explicit recommendations are made to use the statistics provided by WWB to increase the variety in one's writing. However, according to the psychological work on comprehension, variety in reference may easily produce problems for the reader, as will be described more

below, and variety of sentence length in itself has no particular value.

Many of these literary customs are apparently intended to maintain the reader's interest. However, it is reasonable to assume that the reader of a technical document does not have an interest problem. Such a reader is neither a classroom student, struggling to keep awake while reading boring material, nor a casual reader hoping to be entertained. Rather, the reader of a technical document needs to get the information out of the document as quickly and efficiently as possible, so that he or she can complete the task at hand. Certainly, the reason why technical documents are underused is not that they are boring, but that they are inefficient information sources.

A secondary problem is that both systems use fairly simple algorithms; neither of them process the input to any depth. Doing any extensive processing, along the lines of an artificial intelligence natural language system, is out of the question, since these systems run on small machines, such as PDP-11s. But by using the newer and much more powerful machines now appearing on the market as professional work stations, it should be possible to device much more sophisticated writing aids.

#### A NEW APPROACH

A new approach to computerized writing aids is based on using the results and theory from the research literature on comprehension to specify what problems the system should detect. By using techniques from artificial intelligence for the processing of natural language, the greater sophistication can be achieved.

Research in modern psycholinguistics has about a twenty-year history. Of the many topics that have been studied, only a portion of the work is relevant to improving the comprehensibility of text, but this still leaves roughly 200 relevant studies in the literature. Most of these deal with individual isolated sentences, but some of the newer work deals with passage structure or groups of sentences and their relations.

#### Comprehension research results

Examples of comprehensibility results. Table 1 presents some examples of comprehensibility rules that can be proposed based on some of the results in the literature. The first rule is of course a familiar result, and is used in both CRES and WWB. The second rule is a newer idea, and can be motivated both empirically and in terms of theoretical considerations of the information processing that is required to determine the referent of a pronoun.

The third and fourth rules are good examples of how the research can correct standard writer's wisdom. CRES recommends that relative pronouns be deleted, apparently because they

Table 1  
Examples of Comprehensibility Rules  
from the Psycholinguistics Literature

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1. Active is better than passive.  
(Tannenbaum & Williams, 1968)
2. A pronoun should refer to the subject of the previous sentence.  
(Frederiksen, 1979)
3. Relative clauses should begin with a relative pronoun.  
(Hakes & Foss, 1970)
- ... If the topic of the passage is the logical object,  
then passive is better than active.  
(Perfetti & Goldman, 1974, 1975)
5. Temporarily changing the subject impedes processing.  
(Lesgold, Roth, Curtis, & Riley, 1979)
6. Refer to an object in the same way as it was previously referred to; even a synonym slows processing.  
(Yekovich, & Walker, 1978)
7. Refer to an object that was either explicitly mentioned previously, or is strongly implied by the previous text.  
(Haviland & Clark, 1974)
8. Indefinite determiners should be used only on textually new items.  
(de Villiers, 1974)
9. Connective words (e.g., however) improve comprehension.  
(Haberlandt & Kennard, 1981)

---

increase the length of the sentence. However, the empirical work shows that at least under some conditions, sentences with relative pronouns are easier to understand than those without; the pronoun marks the beginning of a relative clause, and so can relieve some local parsing ambiguity. The next rule corrects the blanket condemnation of the passive voice appearing in many writing guides. The research shows that the passive voice has the important function of allowing the surface subject of a sentence to be the same as the topic of discourse.

The fifth rule is an example of recent work done on the role of topic information during comprehension. Changing the topic of discourse is legitimate, but if it is not justified, the reader will be misled and slowed down.

The sixth rule directly contradicts the recommendation that the writer use variety in how things are referred to. Such variety in reference actually costs extra processing. This has not been studied very directly, but there are some clear conclusions, such as the fact that even the use of a synonym can slow down processing. In technical documentation, this issue could be very important. Often there are objects that are very similar to each other, but are distinguished only by the modifiers appearing in the noun phrase. For example, a device might have many relays, which are distinguished by phrases such as antenna excursion limiting cutout relay, and magnetron anode current limit relay. Perhaps in such a context there should be no variety in reference at all.

A related issue is addressed in the seventh rule. In the normal course of comprehension, the writer and reader have a tacit contract that the writer will not refer to objects in ways that the reader cannot match up with previously mentioned or known objects. This means that the writer should ensure that the reader can easily determine what object is being referred to. If a reference is made to a previously mentioned object in an obscure fashion, then the reader must take extra time and effort to resolve the reference.

An interesting result by de Villiers leads to the eighth rule in the Table. This rule would be rarely violated even in poor writing, but it does serve as an example of the kind of consideration that emerges clearly from even simple psycholinguistics work, but which is not treated at all in standard writing textbooks. de Villiers discovered that simply changing all of the appearances of the definite determiner the in a simple passage to the indefinite determiner a will cause the reader to switch from interpreting the passage as a connected story to viewing it as a set of isolated sentences. Apparently, for most readers, the indefinite determiner acts as a extremely strong signal for a textually new item. In contrast, the definite determiner is more ambiguous in its function (see Kieras, in press).

The last example rule listed in Table 1 concerns connective words like however and therefore. These words influence readability formulas because they can increase the length of sentences. Connective words like although compound this problem because they require a much more complicated sentence structure. However, these words should reduce the amount of processing effort, because they explicitly specify the logical relationship between the previous ideas in the passage and the idea that follows. If the connective word is missing, then the reader is put in the position of having to infer the relation, thereby taking extra time and effort.

This sample of results is by no means complete and exhaustive. A large scale review of the comprehensibility results in the psycholinguistics literature can be found in Kieras & Dechert (in preparation). But these examples illustrate how actual empirical and theoretical results argue against many aspects of conventional writer's wisdom, but at the same time give extremely specific suggestions on how to structure text so that it is more comprehensible.

Limitations of the research literature. There are certain limitations of the research literature. First of all, the psycholinguistics studies rarely combine two or more structural features, so there is little information on what writing problems are the most serious ones, or how they interact with each other. Furthermore, much of the work has been done in the context of isolated sentences. While this is convenient experimentally, it is quite rare that the reader of technical documentation must process single isolated sentences. Finally, there are many issues of great importance in technical documentation that have not been considered in the psycholinguistics literature. A good example is the effect of inconsistent terminology. In contrast, there are a great number of studies comparing self-embedded constructions to right-branching, even though self-embedded constructions of any depth are rare.

The conclusion is that given the spotty empirical coverage, it is important to apply theoretical ideas about comprehension, as well as empirical results, to the design of an advanced writing aid.

#### Comprehension theory

The theory of comprehension has been very well developed in the last ten years. Information processing models for comprehension have been elaborated to the point of being expressed in the form of computer simulation models that rigorously specify many of the processes and structures involved in comprehension. These models were based closely on the work on natural language processing being done in the field of artificial intelligence. Some representative simulation theories of comprehension appear in Kintsch and van Dijk (1978), Thibadeau, Just, and Carpenter (1982), and Kieras (1981, 1983). These theories are elaborate enough, and have been compared in enough detail to data, that they

can be used as comprehensive descriptions of the processes that the reader must perform in order to comprehend text. Thus they provide a starting point for defining the processes that an advanced writing aid should perform.

A survey of the theoretical literature is not possible in this paper. However, a good summary of the general theoretical framework can be provided (cf. Kintsch, 1977), and related to the types of possible comprehensibility problems (see also, Kintsch & Vipond, 1979; Miller & Kintsch, 1980). The process of comprehension involves several stages, which are performed sequentially to a great extent, but also interact heavily. Each of these stages can be related to sources of comprehension difficulty. The first stage is word identification, which matches the visual pattern of a printed word to an entry in the reader's internal lexicon. Some of the impediments to comprehension at this stage are very well understood, such as the presence of unknown or low-frequency words. The next stage performs syntactic analysis of the sentence, deriving the relationships of the words to each other. Impediments to comprehension here will consist primarily of complicated sentence structure, such as self-embedded sentences. Then comes semantic analysis, in which the word meanings are associated with each other as specified by the sentence syntax and the previous context, to produce a representation of the meaning of the sentence in terms of how it relates to the previous material. Problems of ambiguity, coherence, reference, and global organization can appear at this stage. The final stages are concerned with pragmatic and functional analysis, in which the concern is what the point of the material is, and how it is related to the reader's situation or task. Comprehensibility problems can appear at this level if the large-scale organization of the material is poor, or it fails to inform the reader of what content is relevant to the task at hand.

#### What is feasible?

Our present knowledge and technology is adequate to allow an advanced writing aid system to identify some of the comprehensibility problems that can occur at each stage of the comprehension process. CRES handles the problems in the word identification stage by identifying unusual and unknown words. CRES also detects some of the problems in the syntax stage by finding some forms of bad sentence structure. Going beyond systems like CRES and WWB, into a full analysis of comprehensibility problems in the semantic and later stages, would require heavy use of general knowledge and also the relevant domain-specific knowledge such as electronics theory. This is well beyond the current state of the art in artificial intelligence, and can be ruled out of this discussion of advanced writing aids. However, there is a certain set of issues in the semantic, pragmatic, and functional stages that are within the reach of current artificial intelligence techniques, and are also very important to comprehensibility. For example, determining whether the material is coherent in certain ways is quite simple.

The key idea in the development of advanced writing aids is the principle that the system does not have to be able to handle input as complex and obscure as human readers can. The goal of an advanced writing aid is only to identify when it is difficult to process the text; the system does not have to be able to overcome all of the difficulties, nor fully understand the input, any more than a poor reader would. This principle, which could be flippantly termed artificial stupidity, is very important, because this is why advanced writing aids are now possible, even though many fundamental problems in both the artificial intelligence and cognitive psychology of language processing are not yet solved.

An advanced writing aid would resemble a model of comprehension, or an AI-based natural language processor, but there are some important differences. The similarities are that the system consists of a parsing process, a set of rules for integrating sentences together, and the use of a working memory to keep track of the current topics and the structures being built. However, the difference is that the level of comprehension required can be quite shallow, as argued above, and thus little or no general knowledge is required. For example, the system can identify and parse noun phrases and maintain a record of which referents have been mentioned, so that it can determine whether a new noun phrase can be easily matched against a previous reference. Likewise, the system could keep track of the current topic by detecting some of the simple patterns in which topics are changed in the course of a passage.

Thus, such a system should be feasible simply because it uses only a subset of what is currently known about natural language processing, both in artificial intelligence and in cognitive psychology. Rather than attempting to be a complete comprehension system, this system will only capture certain aspects of comprehension and then signal when some relatively simple rules have been violated.

#### A demonstration system

A demonstration system along these lines will be briefly described. The demonstration system uses an ATN parser (see Woods, 1970) borrowed directly from the comprehension simulation model described in Kieras (1983). This parser is severely limited, but is able to handle many complex constructions. The ATN parser works in conjunction with a production system interpreter borrowed directly from another comprehension simulation model, this one described in Kieras (1982). The system maintains a semantic network data base, also borrowed from earlier models. It should be kept in mind that this is not intended to be a usable system, or even a prototype of one. Rather, it demonstrates how a simple reorganization of components from existing simulation models of comprehension can be applied to the writing aid problem. A truly usable system will require programming that is more efficient, even if less psychologically relevant.

The demonstration system is set up on a Xerox 1108 LISP machine, using several display windows. One window contains a list of the input sentences, followed by the comments generated for each one. Tables 2 and 3 are copies of these windows. Another window contains a list of the referents currently defined by the passage; the contents of this window appear at the end of Tables 2 and 3. A detail important to understanding the examples is that the names of the referent nodes are arbitrary symbols like R0409. Other windows display the state of the processing for development purposes.

Table 2 shows a series of poorly written sentences, while the passage in Table 3 contains much of the same content, but better expressed. The materials are based on the simulated technical manuals described in Kieras (in preparation). The system implements simplified forms of the comprehensibility rules shown in Table 4.

The operation of the demonstration system can be briefly summarized. The basic principle of operations is the processing of given and new information (see Clark & Haviland, 1977), similar to the model described in Kieras (1981). The principle is that each sentence in a text will contain new information about referents that are given in the context of the preceding sentences. The representations for the given referents are located, and the new information added to them.

The system processes the input one sentence at a time, maintaining a representation of the content of the previously processed sentences. The representation at this time is based on Anderson's (1976) ACT representation, in which a referent is defined by a piece of semantic network attached to a node that represents the referent. In order to allow highly efficient referent searches based on surface structure, a word string that consists of a short adjective-noun phrase is stored as the simple referential form of the referent. The system constructs the ACT network representation for the sentence content and annotates it with tags about the syntactic role played in the surface sentence by portions of the network structure. For example, the proposition node corresponding to the head noun of a noun phrase, or to the main sentence clause, is tagged as such. The referent nodes are tagged to show whether they appeared as surface subject or surface object. This technique allows production rules to easily consider both the syntactic and semantic features of the input.

While processing the input sentence, the parser identifies each noun phrase, and calls the production system interpreter to resolve the reference. The production rules attempt to match the noun phrase to a referent already mentioned, in order to determine whether the noun phrase refers to a textually old referent, or to a textually new referent, and tag the structure as such. The search for a previous referent is a two-stage process. First, the simple referential form, if any, for the surface noun phrase is matched against the simple referential forms for all defined

Table 2  
Sample Commentary on Poor Text

HEADING: THE PHASER SYSTEM

NEW REFERENT defined: R0099

New Discourse Topic: R0099

THE SYSTEM CONTAINS AN ENERGY BOOSTER THAT IS POWERED BY THE MAIN SHIPBOARD POWER SUPPLY

Old referent found: R0099

INCONSISTENT terminology - use: PHASER SYSTEM

NEW REFERENT defined: R0102

Using last two words for simple reference: MAIN SHIPBOARD POWER SUPPLY

EXCESSIVE content in noun phrase

NEW REFERENT defined: R0107

COMPLEXITY imposed - no simple form for new referent

THE BOOSTER RECEIVES HIGH VOLTAGE FROM THE MAIN SUPPLY

Old referent found: R0107

COMPLEXITY unnecessary -- define simple form: BOOSTER

NEW REFERENT defined: R0116

Old referent found: R0102

INCONSISTENT terminology - use: POWER SUPPLY

Sentence subject changes the topic R0099 R0107

Topic change is ok since this is a topic chain R0099 R0107

AN ENERGY ACCUMULATOR IS ALSO USED BY THE SYSTEM

NEW REFERENT defined: R0123

Old referent found: R0099

INCONSISTENT terminology - use: PHASER SYSTEM

INCOHERENT: New referent in sentence subject changes the topic R0123

BAD PASSIVE - subject is not the topic R0107

THE ACCUMULATOR IS ENERGIZED BY THE BOOSTER

Old referent found: R0123

INCONSISTENT terminology - use: ENERGY ACCUMULATOR

Old referent found: R0107

COMPLEXITY unnecessary -- define simple form: BOOSTER

Passive sentence is ok because it preserves the topic R0123

\*\*\* REFERENT LIST \*\*\*

(R0099 (PHASER SYSTEM) (&PHASER &SYSTEM (&CONTAIN) (&CONTAIN R0107) (&USE R0123)))  
(R0102 (POWER SUPPLY) (&MAIN &SHIPBOARD &POWER &SUPPLY (&POWER R0107)))  
(R0107 NIL (&ENERGY &BOOSTER (&RECEIVE R0116) (&ENERGIZE R0123)))  
(R0116 (HIGH VOLTAGE) (&HIGH &VOLTAGE))  
(R0123 (ENERGY ACCUMULATOR) (&ENERGY &ACCUMULATOR))

Table 3  
Sample Commentary on Good Text

HEADING: THE PHASER SYSTEM

NEW REFERENT defined: R0131

New Discourse Topic: R0131

THE PHASER SYSTEM CONTAINS AN ENERGY BOOSTER AND AN ENERGY ACCUMULATOR

Simple reference to: R0131

Old referent found: R0131

NEW REFERENT defined: R0134

NEW REFERENT defined: R0137

THE ENERGY BOOSTER RECEIVES HIGH VOLTAGE FROM THE POWER SUPPLY

Simple reference to: R0134

Old referent found: R0134

NEW REFERENT defined: R0144

NEW REFERENT defined: R0147

Sentence subject changes the topic R0131 R0134

THE ENERGY BOOSTER ENERGIZES THE ENERGY ACCUMULATOR

Simple reference to: R0134

Old referent found: R0134

Simple reference to: R0137

Old referent found: R0137

THE ENERGY BOOSTER SHOULD BE MONITORED CAREFULLY BY THE OPERATOR OF THE PHASER SYSTEM

Simple reference to: R0134

Old referent found: R0134

Simple reference to: R0131

Old referent found: R0131

NEW REFERENT defined: R0155

COMPLEXITY imposed - no simple form for new referent

Passive sentence is ok because it preserves the topic R0134

\*\*\* REFERENT LIST \*\*\*

(R0131 (PHASER SYSTEM) (&PHASER &SYSTEM (&CONTAIN R0134) (&CONTAIN R0137) (&POSSESS R0155)))

(R0134 (ENERGY BOOSTER) (&ENERGY &BOOSTER (&RECEIVE R0144) (&ENERGIZE R0137)))

(R0137 (ENERGY ACCUMULATOR) (&ENERGY &ACCUMULATOR))

(R0144 (HIGH VOLTAGE) (&HIGH &VOLTAGE))

(R0147 (POWER SUPPLY) (&POWER &SUPPLY))

(R0155 NIL (&OPERATOR (&MONITOR R0134))))

Table 4  
Comprehensibility Rules in the Demonstration System

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Reference

1. Referents should be referred to by an unambiguous and short (2-3 words) simple referential form that is used consistently throughout the document.
2. The identity of a referent must be trivially determinable from the referencing noun phrase; no inference should be required.
3. The pronoun it should refer only to the subject referent of the preceding sentence.
4. Propositional pronouns should refer only to the main proposition of the preceding sentence.

Sentence structure

1. Relative clauses must have a relative pronoun (which, that) unless the main proposition of the clause is based on a preposition.
2. A noun phrase should contain no more than about 5 propositions.

Textual Coherence

1. Textually new referents and propositions should appear only in clause predicates.
2. Material should be grouped so that the following coherence rules can be followed: The subject noun phrase of each sentence should refer either to the subject referent of the previous sentence, or to a textually new referent introduced in the predicate of the previous sentence (chained construction), or the discourse topic, defined as the subject of a heading or the first sentence of the passage.
3. Although passive constructions should be avoided, a passive construction that is required to maintain coherence should be used rather than the active construction.

Textual Organization

1. New referents should be introduced in simple referential form, and additional information added in later sentences.

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referents. If a match is found at this point, the search is over quickly. Otherwise, the system must analyze the semantic representation, a much slower process. This strategy corresponds to the hypothesis that if the surface form of a noun phrase is identical to the earlier surface form of the intended referent, processing will be much faster.

If the surface match fails, the second stage in the search is done by a set of production rules which matches the semantic content of the noun phrase, one proposition at a time, against the network representation for the previous passage content, and attempts to find the node whose propositions all match. If more than one such node is found, then a comment is made that the reference is ambiguous. If the noun phrase is successfully matched, then the structure representing the noun phrase is discarded, and replaced with the node for the referent.

If no match is found, the system comments that a new referent is defined, and builds the corresponding network structure. An indefinite noun phrase is always treated as defining a new referent. If the noun phrase for a new referent consists of a short string consisting only of one or two adjectives followed by a noun, it is used as the simple referential form for the referent. Thus, an emitter bias resistor can later be efficiently referred to as the emitter bias resistor.

The final result of parsing and reference resolution is a piece of semantic network structure that represents the textually new content of the sentence. A set of production rules is then applied, which comment on the relation of the surface form associated with the new structure to the previous passage content. Thus, if the surface subject is a new referent, the system will comment on the loss of coherence. If the sentence was passive, but the surface subject was the current topic of discourse, then a comment is made that the passive is present, but acceptable. After completing the commentary, the content of the sentence is added to the representation of the passage content, and processing on the next sentence is begun.

Although this system, as emphasized above, is not actually usable, it does illustrate the soundness and feasibility of the basic concept, and how existing techniques from artificial intelligence and cognitive simulation can be easily applied. A system tailored to the task, using more sophisticated algorithms, such as a Marcus parser (1980), should produce fully usable performance in the near future.

## CONCLUSION

The important practical question is whether such a system would actually be useful if it were built. One reason for being pessimistic is the historical intransigence of the general problem of improving the quality of writing in the real world. But a more serious problem is the ambiguous results of attempts to demonstrate scientifically how writing quality can be improved. Probably the best example is the work done by Duffy and his associates (Duffy & Kabance, 1982; Duffy, Curran, & Sass, 1983), who failed to obtain performance improvements even with drastic changes to technical text. In contrast, experiments reported in Kieras (in preparation) demonstrate strong performance gains resulting from improving the quality of a simulated technical manual. The experimental task was a realistic model of the situations in which technical manuals for equipment are used. The manual was improved by correcting problems that are the type of comprehensibility problem that an advanced writing aid system could detect. However, there are some questionable aspects to these results, which further research will clarify.

The point is that reading comprehension in task situations this complex has not been studied very much, and there are many unresolved methodological and empirical questions. Therefore, before major efforts are made to put a new writing aid system into the field, it will be essential to conduct the appropriate evaluation studies.

FOOTNOTE

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